A Long Quest Towards Improved GHG Inventories

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Outline

- Part I [Guido Franco – PIER/CEC]
  - How accurate are the existing GHG inventories? Some observations
  - PIER supported research projects on GHG inventory methods in California
- Part II [Jorn Herner - ARB]
  - Improving Greenhouse Gas Inventories and Validation Field Studies

Disclaimer

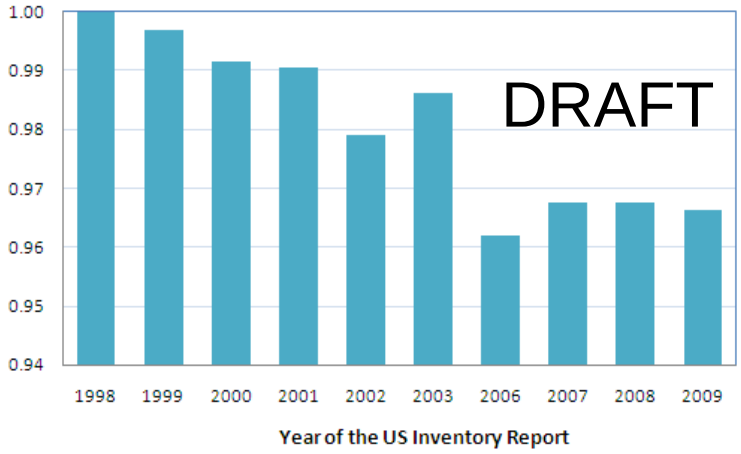
The views and statements including in this presentation do not necessarily represent the views and opinions of the Energy Commission, Air Resources Board, or the State of California

How accurate are the existing GHG inventories? Some observations

CO_2 from the Combustion of Fossil Fuels in the US

- Baseline (1990) US emission estimates reported by the US EPA have gone down since their first inventory released in 1998
- Changes are relatively minor (~ 3%)
- Reported uncertainty -2% to 6%*
- What is the situation with State level data?

Normalized **1990** CO_2 Emissions from Fossil Fuel Combustion – Different Annual US EPA Reports



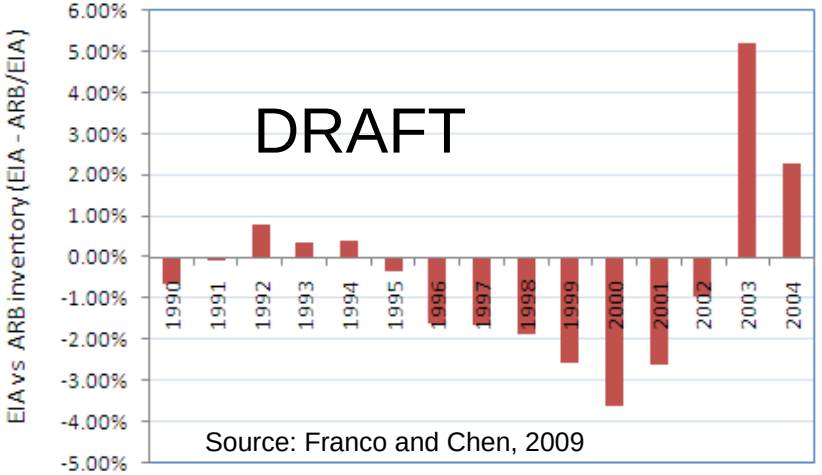
Source: Franco and Oliver, 2009. Data from different US EPA annual inventory reports

* 2009 Draft U.S. Greenhouse Gas Inventory Report. US EPA. February 2009

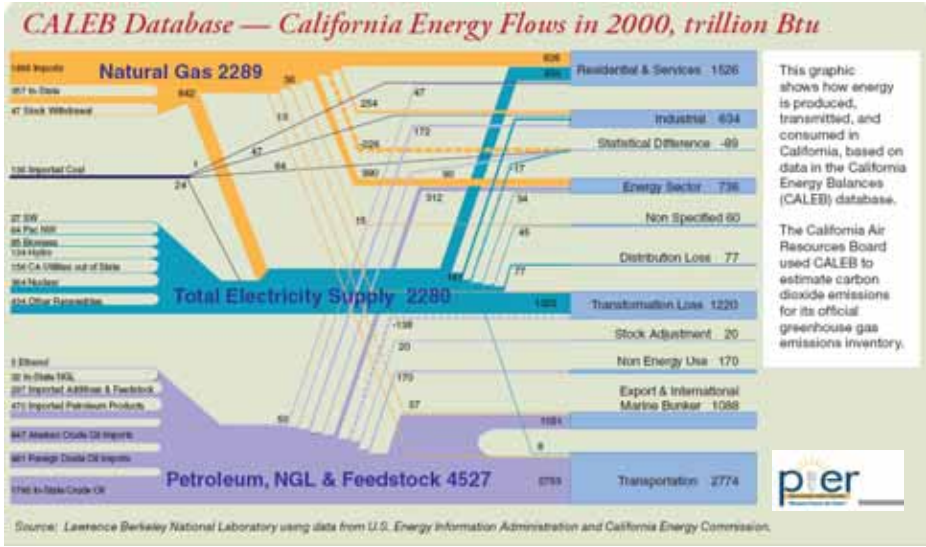
Comparing EIA and ARB Estimates for CA

- In general the CO_2 emission estimates from EIA and ARB are relatively close.
- ARB used the CALEB data set prepared for PIER by LBNL but ARB enhanced CALEB for the inventory.
- Comparing CALEB with secondary sources suggests that the largest sources of uncertainty* are:
  - differences between supply and consumption data (-2% to +4%)
  - carbon emission factor uncertainties (-1% to +5%)

Relative Differences of CO_2 Emissions from the Combustion of Fossil Fuels in California: EIA vs ARB



Source: Franco and Chen, 2009



* Source: LBNL 2008

Non-CO_2 gases

- IPCC/US EPA methods are highly uncertain
- Estimated US 1990 baseline year N_2O emissions from the application of fertilizer have changed substantially
- Estimate of CH_4 emissions from landfills are stabilizing but…….
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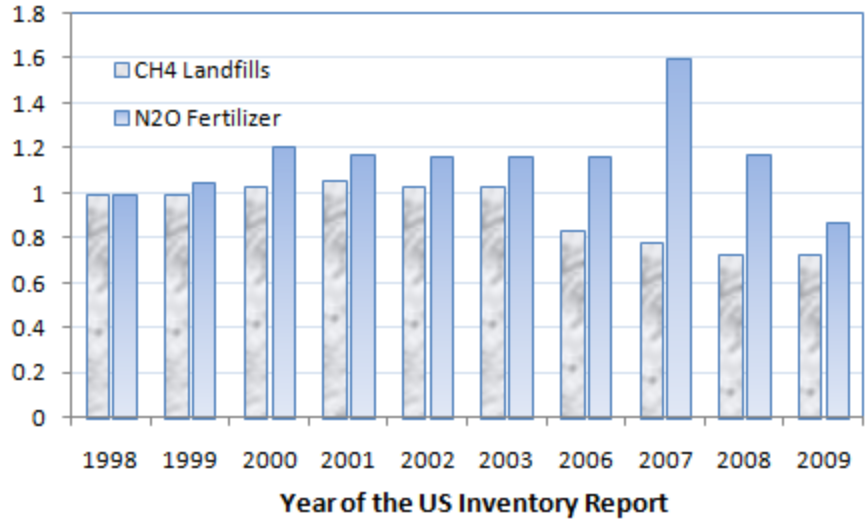
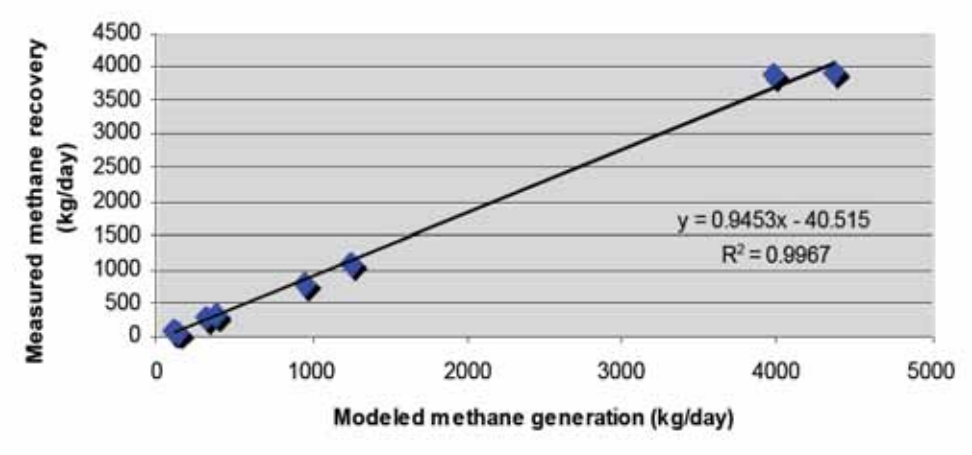
Normalized **1990** CH_4 from Landfills and N_2O Emissions From Fertilizer Applications

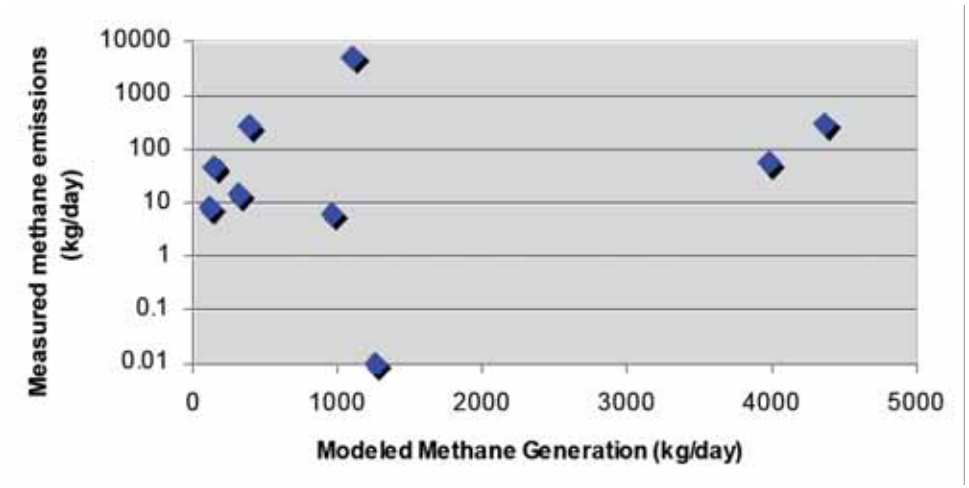


Modeled Methane Landfill Generation* is not a Very Good Predictor of Emissions

- Current Inventory Method

  emissions = (generation – recovery) x (1 – OF)
- Assumed cover soil oxidation fraction (OF) = 10%
- Estimated error is about -37% to 18% **
- However, the error can be much larger if there are fundamental structural problems with the method used to estimate emissions





*using a multi-component first order kinetic model and detailed waste input data

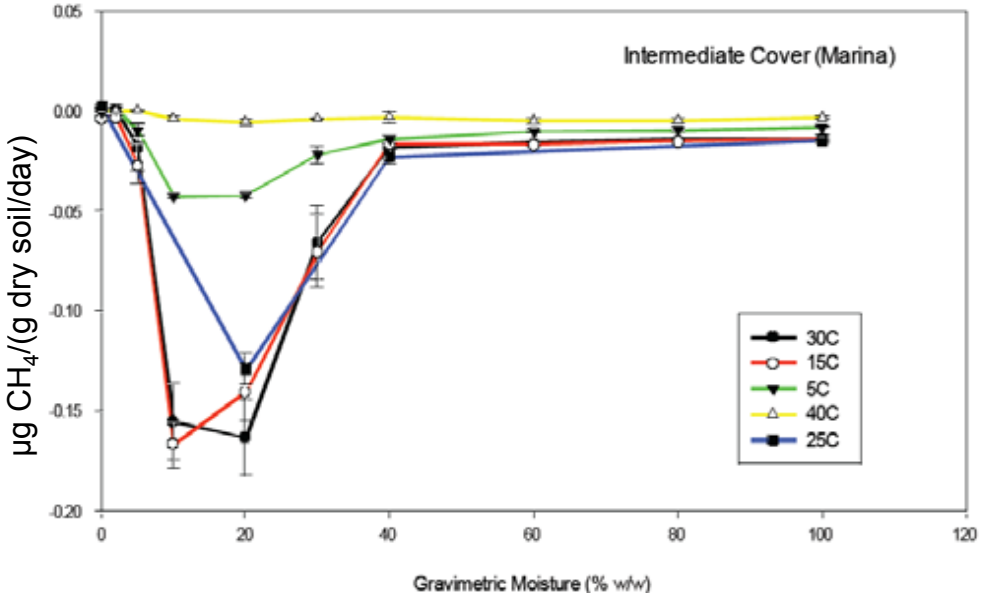
** 2009 Draft U.S. Greenhouse Gas Inventory Report. US EPA. February 2009

Source: Jean Bogner. TAC meeting March 11, 2009
Spokas et al. 2006

Methane Oxidation Rates as a Function of Moisture and Temperature

(Marina Landfill, CA)

- Oxidation is a function of multiple factors including moisture, temperature, and type of cover
- A new model (IPPC Tier 4) is being developed for CA



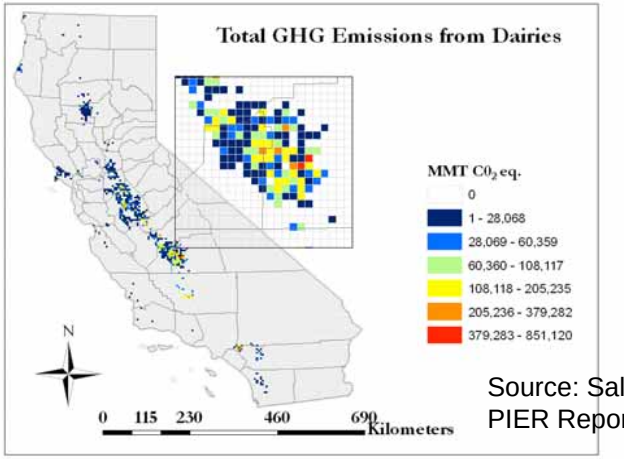
Soil incubation experiments

Source: Jean Bogner. TAC Meeting. March 11, 2009

PIER Supported Research Projects in California

GHG Inventory Methods: PIER Projects

- California Energy Balances: Phase II
- Non-CO_2 gases:
  - Methane emissions from landfills (IWMB, ARB)
  - GHG emissions from dairy farms (CDFA, ARB)
  - N_2O emissions from fertilizers (ARB, CDFA)
  - Net GHG emissions from C sequestration in terrestrial ecosystems (DWR, USGS, ARB)
- Measurement of GHG in ambient air (ARB, NOAA)
- Fugitive methane emissions from the natural gas system (ARB)



Source: Salas et al., 2008 PIER Report

Relevant PIER Reports

- Observation of CH_4 and other Non-CO_2 Green House Gas Emissions from California (Forthcoming)
- Discussion paper on GHG inventory methods: research needs. September 2008.
- Developing and Applying Process-Based Model for Estimating Greenhouse Gas and Air Emissions From California Dairies. Feb 2009
- Assessment of Greenhouse Gas Mitigation in California Agricultural Soils. Jan 2009.
- Summary of Rangelands A Suitable for Terrestrial Carbon Sequestration In Shasta County. Feb 2008.
- Carbon Supply from Changes in Management of Forest and Rangelands in Shasta County, California. June 2007.
- Assessing Impacts of Rangeland Management and Reforestation of Rangelands on Greenhouse Gas Emissions: A Pilot Study for Shasta County. Feb 2007.
- Carbon Supply from Changes in Management of Forest, Range, and Agricultural Lands in California: Forest Fuel Reduction. October 2006.
- Development of an Implementation Plan for Atmospheric Carbon Monitoring in California. August 2005.
- Research Roadmap for Greenhouse Gas Inventory Methods. July 2005
- Development of Energy Balances for the State of California. June 2005.
- Baseline Greenhouse Gas Emissions for Forest, Range, and Agricultural Lands In California. December 2004.
- Quantifying Carbon Dynamics and Greenhouse Gas Emissions in Agricultural Soils of California: A Scoping Study. October 2004

http://www.energy.ca.gov/publications/searchReports.php?pier1=Climate%20Change

- Improving GHG Inventory methods will require well funded and well coordinated research programs at the local, state, and federal levels. What ARB and CEC are doing is a good starting point.
- Every state agency with expertise/responsibility for different sources must be involved (e.g., CalFire and carbon stocks in forest)
- Long-term ambient monitoring must be continued and enhanced. Inventories with adequate temporal and spatial resolution are also needed.
- Maybe it is time to harmonize criteria and GHG inventories. There is a danger in trying to use existing models which may rely on indirect activity data (e.g., miles travelled) instead of more easily observable data (e.g., fuel consumption)

See disclaimer

Improving Greenhouse Gas Inventories and Validation Field Studies

Jorn Dinh Herner
California Air Resources Board

California Environmental Protection Agency
AIR RESOURCES BOARD

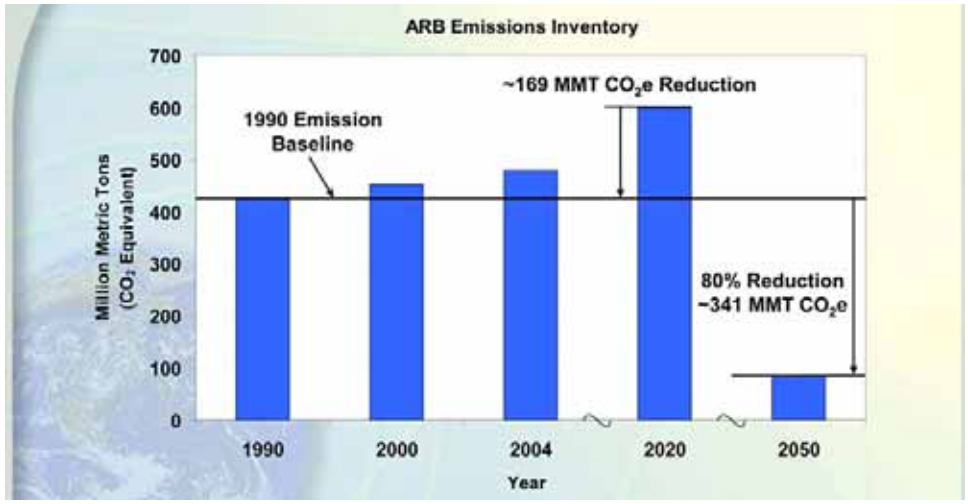
Legislative Drivers

- Assembly Bill 1493
  - Reduce GHG emissions from motor vehicles
- Assembly Bill 32
  - The State Board shall determine what the statewide greenhouse gas level was in 1990, and approve a statewide greenhouse gas emission limit that is equivalent to that level, to be achieved by 2020
- Assembly Bill 1803
  - Directs ARB to prepare, adopt, and update the California GHG Inventory

California Governor Arnold Schwarzenegger signs AB32

Purpose / Goal

- Inform the process to reach the AB32 Target
  - Support regulatory efforts
  - Assess the effectiveness of the mitigation program
  - Validate the GHG Inventory
  - Identify new sources / Improve emission factors
- Use a combination of in-house , collaborative, and extramural research

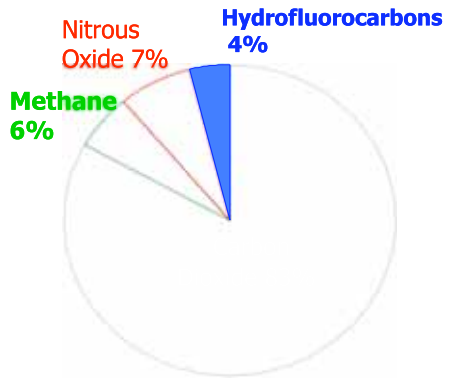


Strategy

- Apply same principles that has guided the last 20 years of research and improvements in vehicular emissions inventories to GHG inventory.

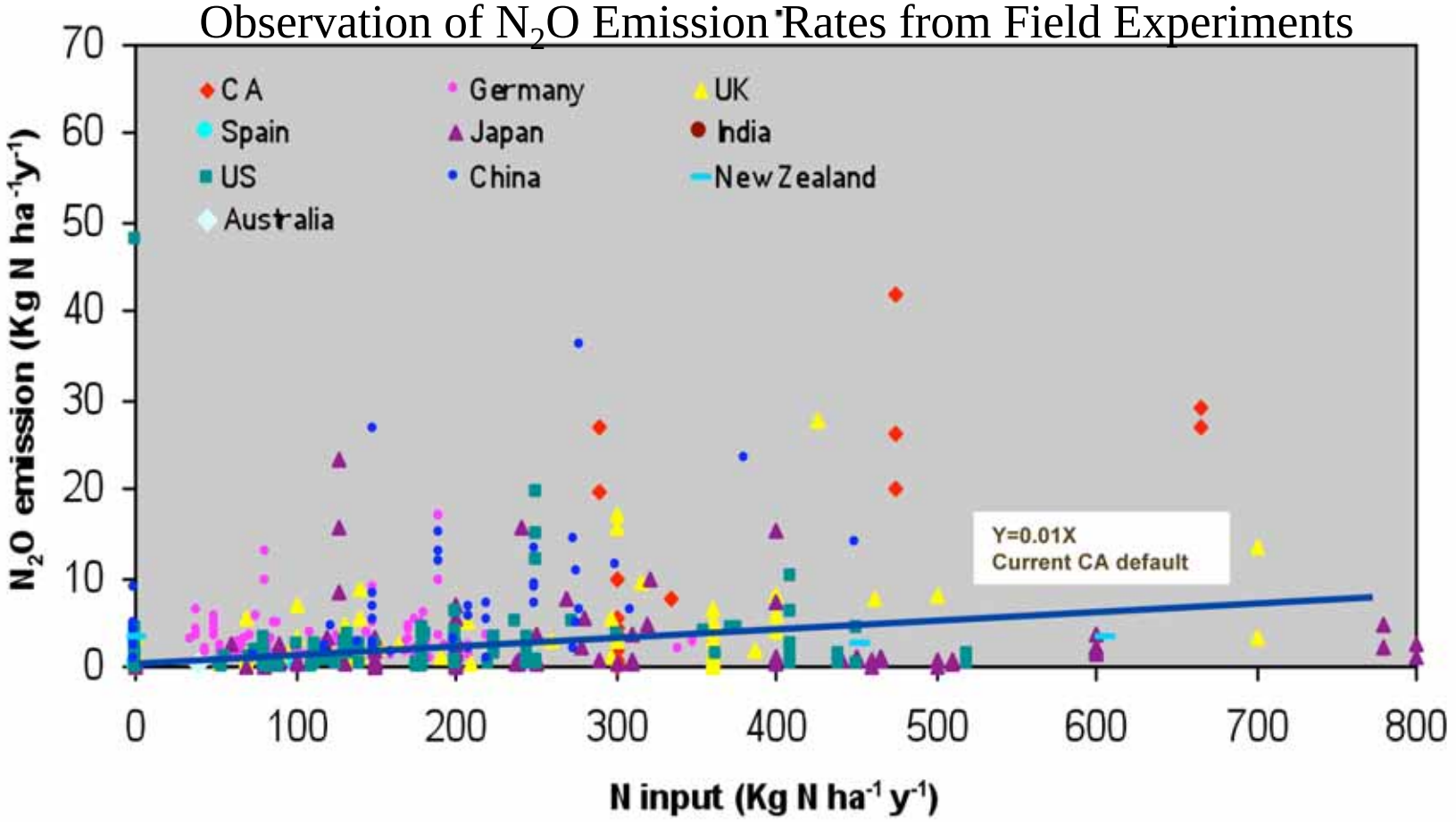
- Coordinated extramural, interagency, and in-house efforts

- Efforts on CO_2 as well as other GHGs, such as N_2O, CH_4, HFCs, ODSs, and Black Carbon
  - Regional validation studies
  - Measure individual sources



CA GHG Inventory 2002

Improving N_2O Emissions Estimates



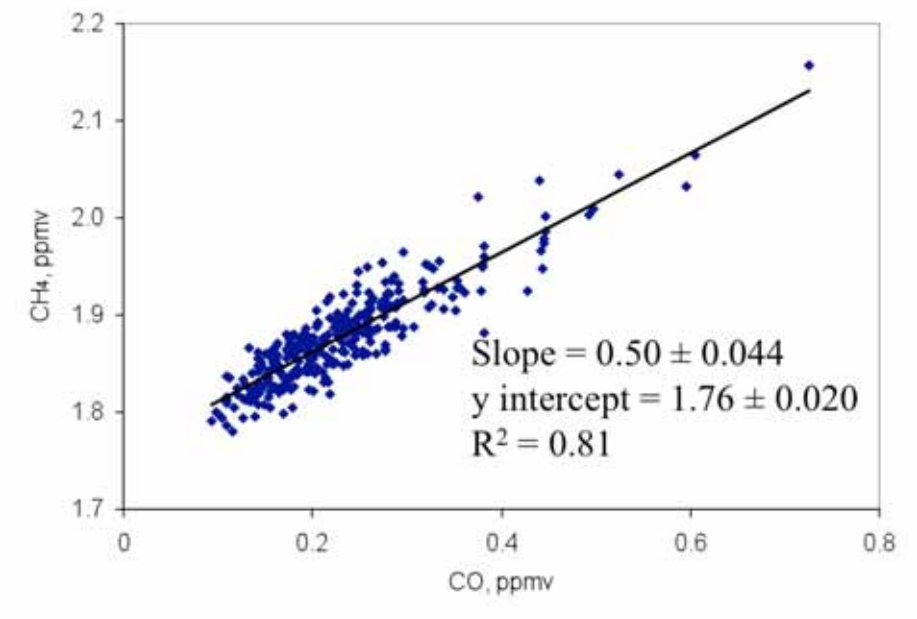
1. N_2O Emissions from the Application of Fertilizers in Agricultural Soils (CEC)
2. Measuring and Modeling N_2O in CA Cotton, Corn and Vegetable Systems (CDFA)
3. How to Reduce N_2O Emissions from Nitrogen Land Application (ARB)

Improving Methane Emission Estimate

- The daily sea breeze pushes urban air against the base of the San Gabriel Mts. and solar heating provides vertical motion.
- The very steep, south-facing slope provides strong, rapid upslope flow of well-mixed air from the urban lowland mid-morning to early evening almost every day.
- Subsidence flow replaces the urban air with uncontaminated air from the lower free troposphere (LFT) at night, generally from the eastern North Pacific Ocean.

Improving Methane Emission Estimate

Mt Wilson – Los Angeles County Methane Emissions



ΔCH_4 = 0.50 x ΔCO (based on correlation slope)

2007 LA County CO inventory 1,800 metric tons/day

CH_4 emissions = (CO metric tons) x 0.50 x (16/28)
= 4.0 MM tons CO_2 eq./year

Methods	LA County CH_4 [MM Tons CO_2 eq./year]	Notes
CH_4 to CO Scaling Measured at Mt. Wilson	**4.0 ± 0.35**	Estimate
CARB CH_4 inventory	**3.0**	IPCC methods

Improving Methane Emission Estimate

Establish a California Pilot Methane Network

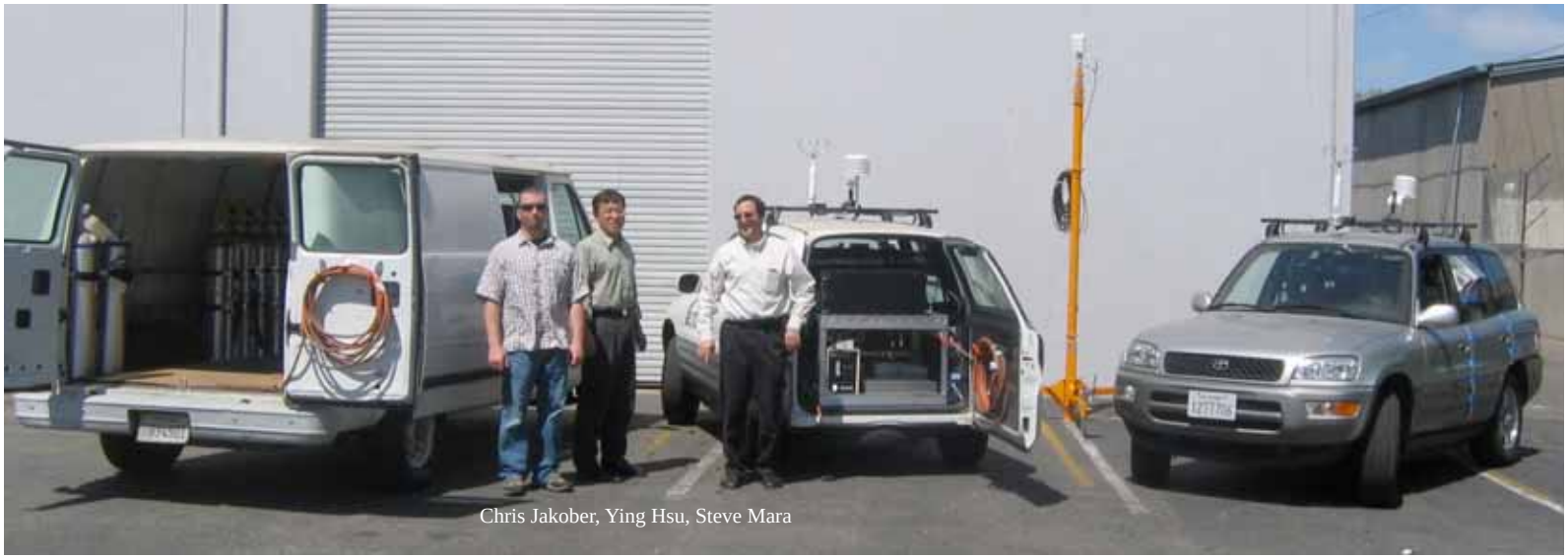
- Provide greater spatial and temporal detail
- Establish additional stations in California measuring CH_4, CO_2 and CO to get coverage of the Central Valley (ARB)
- Build on modeling work already funded by CEC
- Develop inverse models to validate methane inventory and find over or underestimated sources (extramural)

Tranquility Methane Network Site. Photo by Ying Hsu

Improving Methane Emission Estimate

Measure Individual Sources

- Develop the ability to measure GHG from individual sources:
  - Two electric vehicles capable of measuring CO_2, CO, CH_4, N_2O, $PM_{2.5}$, BC, Temp, RH, Wind speed and direction, position (GPS).
  - Use dispersion models, tracer gas release and flux chambers to make measurements



Chris Jakober, Ying Hsu, Steve Mara

Improving Methane Emission Estimate

Measure Individual Sources

CalNex 2010

"Research at the Nexus of Air Quality and Climate"

Combine the resources of NOAA and ARB in a major field study to achieve a step change in our understanding.

- Some species affect both air quality and climate
- Measurements not previously possible
- Address the entire State and over the Pacific
- Answer foundational science issues

Thanks!

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